Harnessing nonlinearities in micro- and nano-electromechanical systems (M/NEMS)

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As the critical dimension of the mechanical devices steadily approaching micro and nanoscale, nonlinear behaviors become inevitable. For example, the simple law of F = -kx needs to be amended with a cubic term (~ x^3) to account for the elastic nonlinearity. Usually such nonlinearities are considered detrimental as they reduce the dynamic range of the devices, and introduce additive noise. In this talk, I will discuss three cases that harness the unique nonlinearities in MEMS and NEMS. The first case is an autonomous silicon MEMS oscillator being driven deeply into the nonlinear regime, that allows for strong coupling between two different vibration modes. The second case is a self-sustaining graphene NEMS oscillator enabled by nonlinear damping, whose oscillation frequency can be tuned by applied gate voltage. The last case exploits the nonlinear electrostatic force in a graphene NEMS resonator, where the combination of small initial strain and high sample quality allows us to observe the chemical potential and quantum capacitance oscillations across different quantum Hall states, through tracking the shifts of mechanical resonance in an applied magnetic field.